

From smallholders to big farms: leveling of termite mounds dominates soil organic carbon variation in miombo woodlands

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Background: distribution of large termite mounds

- Large termite mounds exist intensively in the miombo woodlands of south-central Africa.
- Density: 3-5 mounds per hectare. Height: up to 9 m.

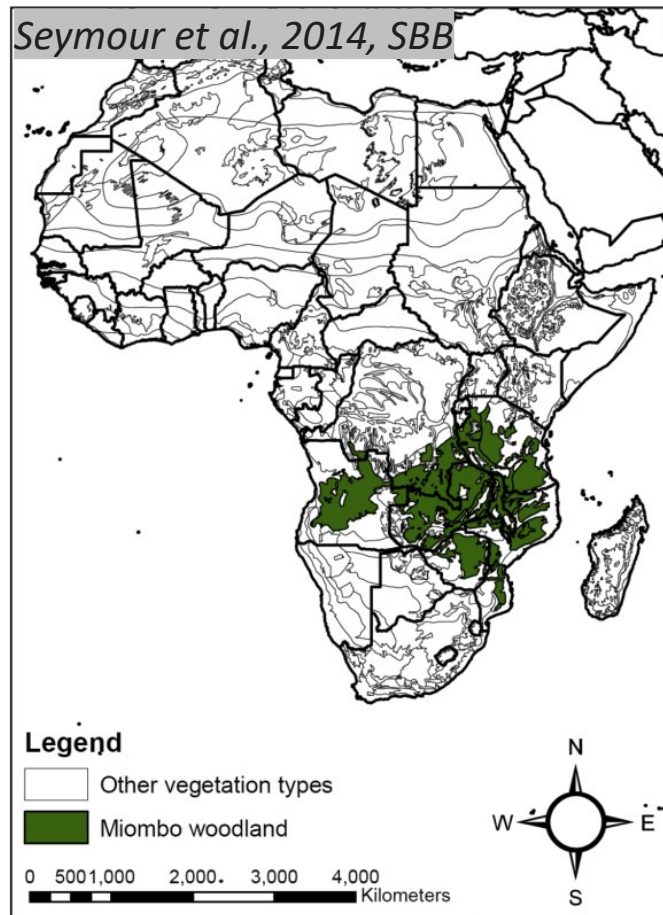


Fig.1. Large termite mounds in miombo woodlands.

Termite mounds represent a substantial amount of material!

- Mound material has higher nutrient concentrations.

Nutrient islands

Foraging termites concentrate plant material in mounds, where fungi process it into soil-enriching nitrogen, phosphorus, and organic material, fostering more plant and animal growth. Mounds also retain water better than surrounding soil.

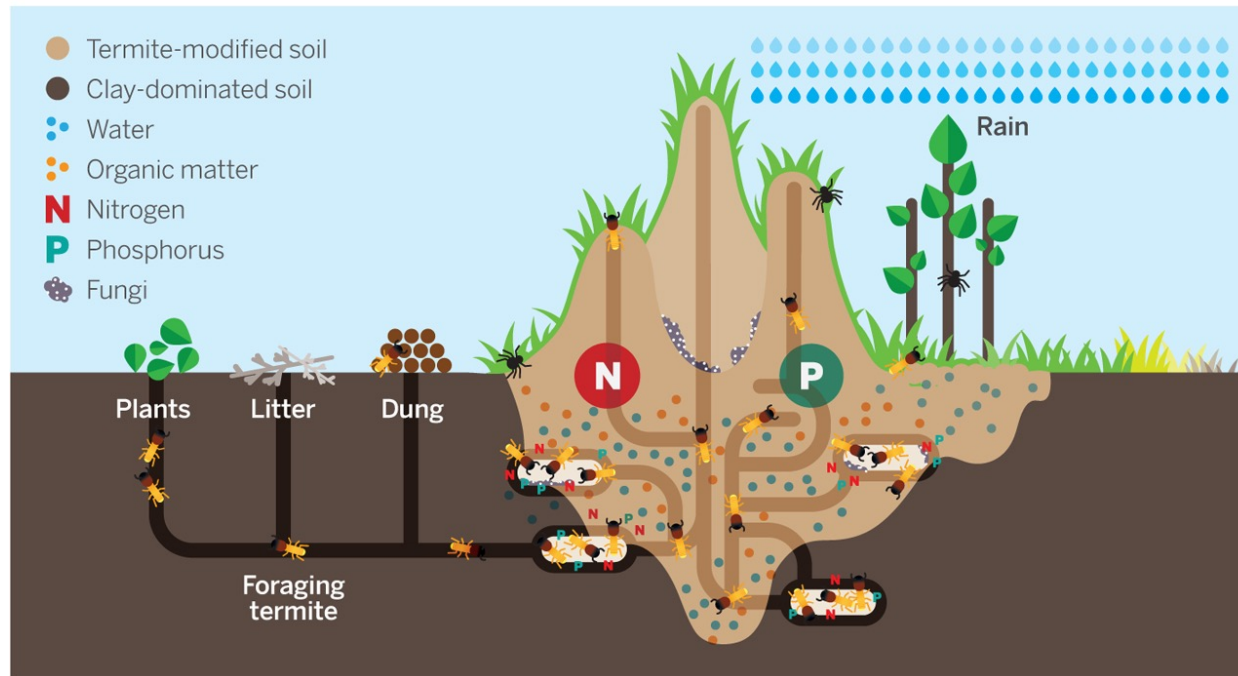
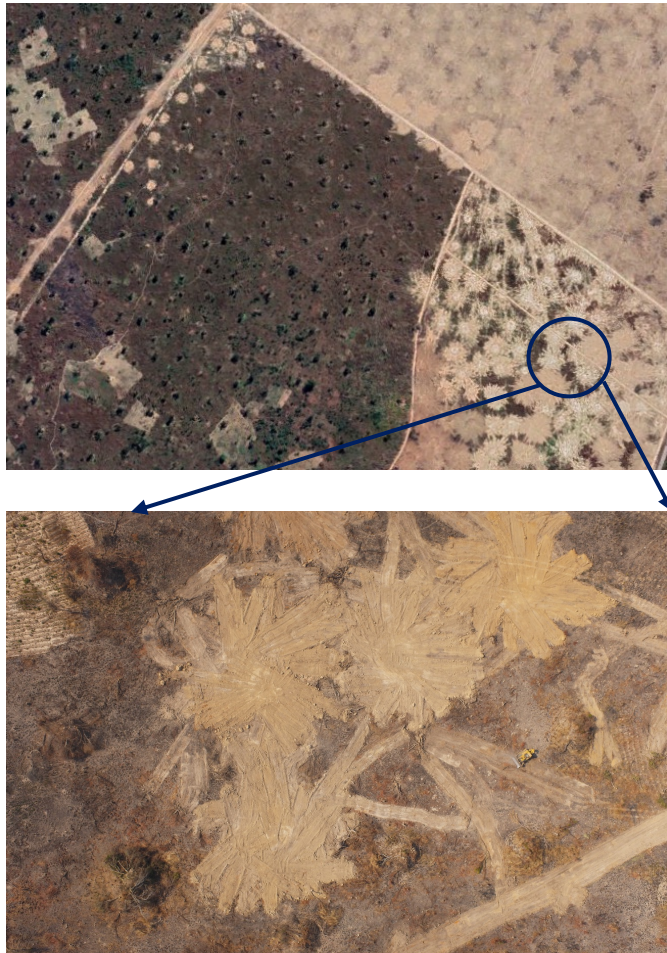


Fig.2. Heterogeneity induced by termite mounds (*Pennisi, 2015, Science*).

- When it comes to soil organic carbon (SOC), yet there is no consensus.

In recent years, commercial farms have been introduced to the region, and termite mounds are leveled for cultivation.



Questions

After the leveling of termite mounds,

1. How does SOC change?
2. How much of SOC variation can be explained by the pre-existing termite mounds?

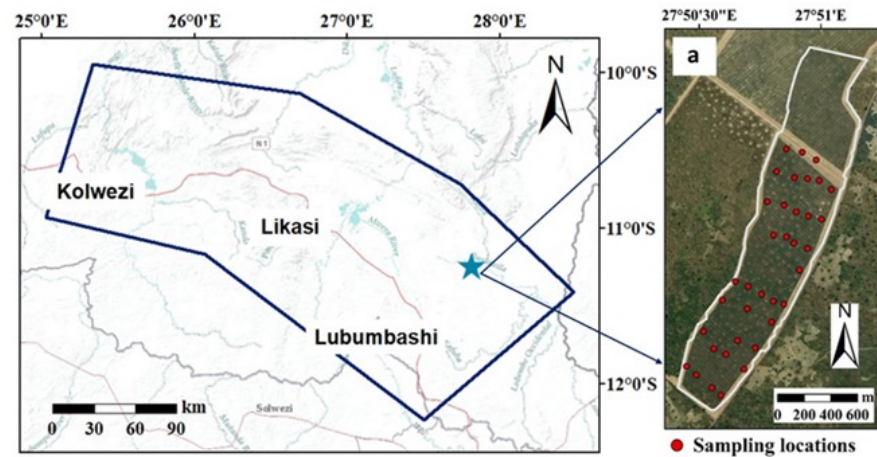


Fig.3. Study region (1.5 km²).

Hypothesis: termite mound properties control SOC change and spatial patterns.

To answer question 1:

After the leveling, how does SOC change?

- ✓ Paired sampling in between-mound area, before and after the leveling.

Sampling depth: 0-25 cm. Sample size: 36.

To answer question 2:

After the leveling, how much SOC variation can be explained by pre-existing termite mounds?

- ✓ Step 1: UAV survey and classification of termite mounds.
- ✓ Step 2: Use hypsometric integral (HI) to characterize the termite mounds.
- ✓ Step 3: Modeling: $SOC \sim HI$.

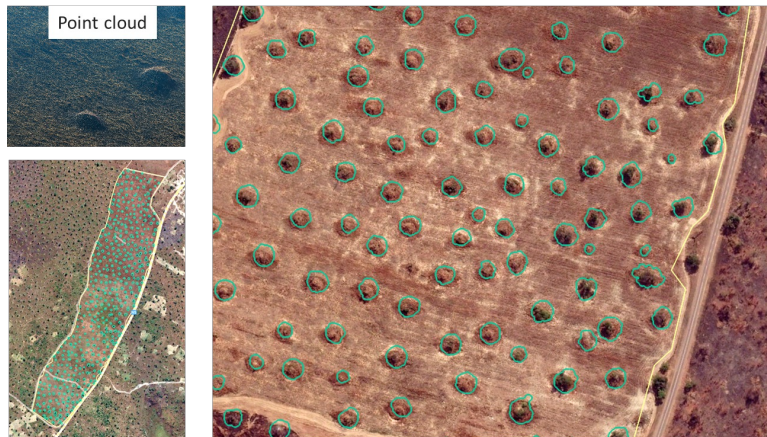


Fig.4. Termite mounds classification.

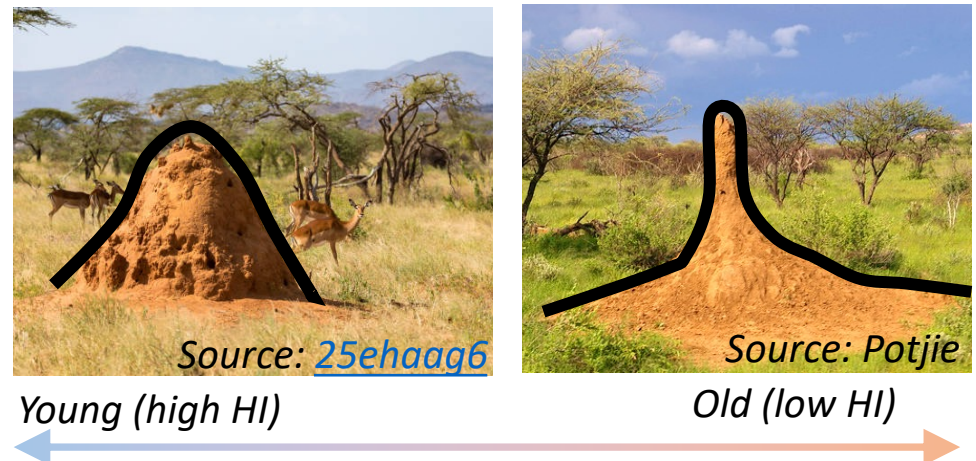
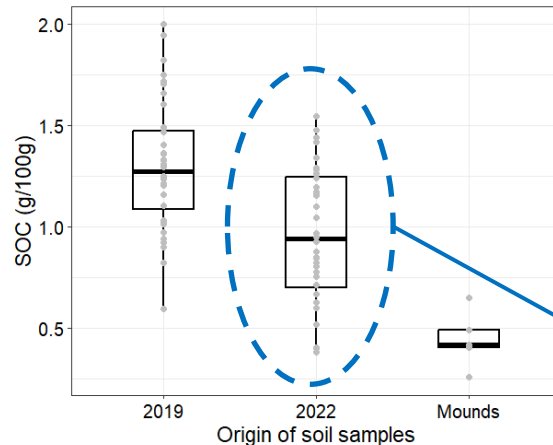


Fig.5. HI to infer the age of the mounds.

Result 1 A significant decrease in SOC was observed ($p < 0.005$).



SOC content (g/100g)

- Before (2019): **1.30 ± 0.32**
- After (2022): **0.96 ± 0.33**
- Within the mounds (n=5): **0.45 ± 0.14**

Greater variation was observed after the leveling!

To explain this...

Result 2 Linear regression showed HI was the most influential variable.

Variable (normalized)	Coefficient	p-value
Clay content	0.12	0.45
HI	0.45	0.01
D1	0.18	0.25
TWI	0.24	0.12

- Sample size=36
- $R^2=0.42$ ($p=0.0018$)

(While no significant factors were found to contribute to pre-leveling SOC...)

Conclusion

- The transition from smallholder to commercial farms led to decrease and greater variation in SOC.
- Much of this variation could be explained by termite mounds.

Future work

- SOC mapping based on Sentinel-2.
- Substantial challenges associated with large small-scale spatial heterogeneity.

